Spotify Clone: A Blockchain-Powered Approach to Royalty Management and NFT Music Distribution

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***Abstract*— Blockchain technology, which rests on impermeable, decentralized ledgers, has found use in a variety of fields beyond its original connection to cryptocurrencies. Its main strength is its capacity to produce records that are secure, readable, and immutable. By using blockchain technology, this initiative offers a new method of music distribution that eliminates the need for middlemen by allowing artists to sell their music directly to consumers. The system records and authenticates music transactions using a decentralised ledger to ensure safe and transparent transactions. Smart contract-enabled automated royalties distribution guarantees fair compensation for artists. By avoiding traditional middlemen, musicians have greater control over their revenue and creative property. The site also has an intuitive user interface that makes it simple for artists to submit, maintain, and make money off of their creations. This innovative approach fosters direct connections between musicians and fans while lowering worries about financial leakage and piracy, leading to a more equitable music industry.**

Keywords— Blockchain, Decentralized Applications, NonFungible Tokens, Royalty, Smart Contracts, Tokenization.

I. INTRODUCTION

The anarchistic and decentralised technology known as blockchain forms the core of cryptocurrencies, most notably Bitcoin. It functions as a distributed, impermeable ledger that gives a network of computers a transparent, secure way to preserve records. Unlike traditional centralised databases, blockchain relies on a consensus process among its users to confirm and agree upon the ledger's present state. The term "blockchain" refers to the structure and data storage [1].

The data is arranged into blocks, each containing a variety of transactions or information. A chain is formed by the chronological connections between these components. With cryptographic hashing protecting each block, the network's consensus maintains the chain's integrity. Decentralisation is among the key characteristics of blockchain .Blockchain technology has become prevalent in many other sectors and has evolved beyond its beginnings in cryptocurrencies. It provides an easy-to-use, efficient, and unreliable way to monitor and verify transactions. Blockchain is suitable for applications where data integrity and trust are crucial, such as voting systems, supply chain management, healthcare, banking, and, as the previous discussion shown, the distribution of digital assets like music, due to its resilience to manipulation.

Smart contracts, which are self-executing agreements with the terms of the transaction clearly encoded in code, further broaden the potential applications of blockchain technology. These contracts automate and carry out preset criteria, increasing the reliability and effectiveness of many processes. All things considered, blockchain technology has the power to completely change conventional procedures by providing more security, transparency, and productivity for a wide range of uses.

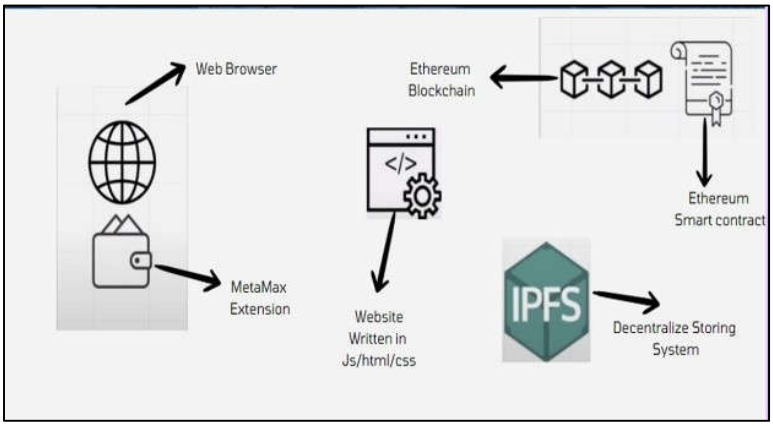

Fig. 1. Navigation of the Path of Blockchain

Blockchain transforms the music industry by establishing a decentralized distribution system, enabling artists to directly connect with consumers while eliminating intermediaries. By automating and guaranteeing transparent royalty payments, smart contracts promote equitable compensation and reduce conflict. Tokenisation with Non-Fungible Tokens (NFTs) enables unique digital ownership and creates new markets for exclusive content. Because of its transparent and immutable nature, the blockchain safely records transactions, protecting artists' intellectual property and lowering the risk of piracy.

Five Key forces of blockchain technology can serve as a platform to protect artist rights

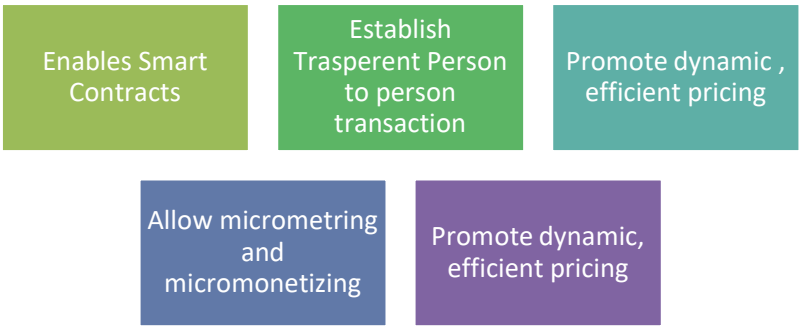

Fig. 2. Exploring Blockchain's Potential in Music System

Micropayments enable flexible payment options and enhance direct communication between artists and fans. By enabling fractional ownership of music rights, tokenisation enables fans to finance the work of artists. Global access to a wide variety of music is made possible by this system, and musicians can learn about the musical tastes of their audience. Furthermore, the decentralized network's resilience improves dependability and ensures an adequate framework for music distribution in the not-too-distant future.

II. LITERATURE REVIEW

To have a comprehensive understanding of blockchain, many research papers were thoroughly examined. Following is a survey of those articles. This research promotes providing free-to-mint NFTs as user incentives, offering free-to-mint NFTs as user incentives, and enhancing user experience through token rewards. The approach integrates DAOs and NFTs to provide new revenue streams, emphasising the reciprocal interactions among artists, users, marketers, and platform staff. The listen-to-earn model, which is especially effective in underdeveloped areas, could pay

musicians 5.6 cents each stream and customers 28.8 cents per hour. The team's revenue strategy, which pays out $1.44 per hour listened, requires a substantial user base in order to meet its $1 million annual aim. Two hours are spent streaming daily by 95% of daily active users. This approach offers a practical and innovative framework for utilising a Web3-based listen-to-earn platform to revolutionise the music industry's economics. [1], [9].

In order to facilitate worldwide music dissemination, the article offers a music representation model that places an emphasis on content similarity and associated tags. The proposed music management system includes modules for distribution analysis, settlement analysis, transmission analysis, and generation analysis. Music categorisation systems use tag-based vectors to automate the categorisation process. The paper also presents a blockchain-based music distribution infrastructure that enhances transparency, security, and integrity. The blockchain system includes nodes for music asset registration, copyright distribution, and user involvement. The framework includes an operational flow, a block transaction architecture, and transparency standards. Lastly, the strategy addresses music copyright concerns, promoting fair and open distribution, which may have implications for bigger content companies in the future.[2].

The impact of blockchain technology on the music industry is the main topic of discussion, especially in light of Web 3.0 and its different blockchain applications. The use of NFTs (non-fungible tokens) is a crucial application that is revolutionising the commercialisation of digital music assets. The article offers a prototype for the "Music-Owner," a Solidity-based smart contract intended to safeguard music ownership and guard against copyright infringement. It has been demonstrated that integrating blockchain technology has several benefits, including transparent music data tracking, fighting counterfeit tickets, and guaranteeing equitable royalties. The conclusion emphasises how blockchain can improve accessibility and encourage a healthy work-life balance in the sector [3]. Quantum Homomorphic Encryption and Quantum ZeroKnowledge Arguments are used in the proposed blockchain technology, which is built on Hyperledger Fabric, to protect intellectual property related to music. Smart contracts are used to activate Non-Fungible Tokens (NFTs), which are used to represent music files. To improve copyright protection, the system uses artificial intelligence algorithms to make intelligent recommendations. Processing large amounts of data and resolving problems like the cold start issue and overspecialization in suggestions present hurdles even with good security. These areas highlight the system's dedication to defending the rights of musicians and the larger music business, and also call for additional research to increase reliability [4].

The topic of conversation centres on how blockchain technology is affecting the music business, especially in light of Web 3.0 and its different blockchain variations. One important use that is revolutionising the commercialisation of digital music assets is the usage of non-fungible tokens, or NFTs. A template for a Solidity-based smart contract called "Music-Owner," which is intended to safeguard music ownership and guard against copyright infringement, is presented in this paper. Blockchain integration has been demonstrated to have several benefits, including transparent music data tracking, fair royalties, and protection against fake tickets. The potential of blockchain to improve accessibility and encourage a healthy work-life balance in the sector is highlighted in the conclusion. [5].

Blockchain has the potential to be used in areas such as networked music copyright databases, fast royalty payments, transparency, and alternative capital sources. This was demonstrated by startups with solutions like DEEPDIVE, LÜM, ECHOWE, and FIBRE. Blockchain is revolutionising the music industry by establishing a worldwide register for creatives, leveraging metadata for information and licencing, deploying smart contracts for immediate royalty distribution, and increasing value chain transparency. The paper highlights the potential advantages of blockchain technology for the music industry, including micropayments, networked databases, transparency, and access to other funding [6],[9].

An NFT-based method for licensing and royalties that works with both open-source and commercial software is described in this study. Entities including developers, customers, and processors are involved in the design's decentralised elements, which include storage and smart contracts. ERC-1155 smart contracts, an aggregator, and a marketplace are essential components. Both centralised and decentralised storage options are used to store metadata information and assets. The procedure includes software weight computation as well as publication and purchase techniques. Decentralised apps (dApps) facilitate interactions between entities. Testing, security analysis, and financial considerations are all covered in the study, which also looks at other uses outside of software, like trademark licensing, real estate leasing, and royalties from artwork. By utilizing NFTs and blockchain technology,

the suggested solution seeks to address concerns with efficiency, equity, and transparency in the distribution of royalties across a range of businesses [7].

The two primary parts of the system are Audio Fingerprinting and Hash Generation. In order to detect instances of copyright infringement, the Hash Generation module creates distinct hashes from songs that are uploaded and published on IPFS. These hashes are then compared. IPFS uses cryptographic hash techniques to ensure data integrity. The Audio Fingerprinting module records song output, converts it to wav format, and then uses the Fast Fourier Transform (FFT) to examine frequencies. This method creates a library of song information and signatures by generating signatures based on frequency intervals. This database is compared to new uploads to identify copyright issues. Users get feedback based on the success of their submissions. The song is added to the system's database and deemed copyright-free if the feedback is good; if it is not, copyright problems are identified and the upload is denied. Royalties are transmitted via a decentralised app, and artists receive payment based on a predetermined formula. Performance metrics such as Transaction Per Second (TPS) and latency rate are provided to evaluate the system's efficacy [8]. BMCProtector, an Ethereum-based application, was developed to provide artists with a decentralised platform for copyright protection. It enables independent copyright administration, ensuring nearly all profits without the involvement of intermediaries. The method uses blockchain technology to track the songs' path of distribution and employs encryption and digital watermarking to safeguard copyright. Versioning protects data integrity during modifications, and smart contracts are utilised to automatically award royalties. Overall, BMC Protector combines blockchain, encryption, watermarking, and access control to offer comprehensive copyright protection [9].

III. METHODOLOGY

The research follows a meticulously crafted methodology, delving into the complexities of creating a decentralized music player platform that leverages the Ethereum blockchain, IPFS, and Non-Fungible Tokens (NFTs) to revolutionize music ownership, distribution, and artist compensation.

A. Smart Contract Development

The Clarifying smart contract guidelines for music ownership, transactions, and royalties is the foundation's main goal. These contracts are coded in Solidity during the implementation phase to guarantee their durability and integrity through stringent testing protocols. The decentralised music player platform is built on the development of smart contracts, which serve as a crucial layer that includes ownership, transactional logic, and automatic royalty distribution. The process is methodical and detailed, covering the security, testing, implementation, and specification of these self-executing contracts.

One of the most important steps in creating smart contracts is gathering requirements. Examples include providing a safe and transparent transactional framework for buying, selling, and transferring music ownership tokens, as well as a mechanism for reflecting music ownership through Non-Fungible Tokens (NFTs) that are unique, indivisible, and transferable. This involves setting guidelines for confirming ownership and approving transfers. In order to eliminate the need for middlemen, the smart contract should have logic for the automated distribution of royalties to artists. Royalties would be calculated and disbursed in accordance with predetermined guidelines.

Converting the specs into executable Solidity code is the implementation stage of developing smart contracts for the decentralised music player platform. This method stands out for its focus on ensuring the smart contract's efficiency and security, attention to detail, and adherence to best practices.

a) NFT Contract Implementation

In terms of how music ownership is represented on the platform, the NFT contract sets the standard. Smart contract features are introduced to allow for the minting of NFTs when new music is posted to the platform. Every token that is minted represents a distinct musical composition and contains metadata like as track and artist details. The goal of the contract is to facilitate users' safe transfer of NFTs. Events that take place as a result of ownership transfers update the status of the contract, guaranteeing that ownership changes are accurately and openly documented. To

ensure that relevant information about the music, like as the artist, title, and genre, is available on-chain, the contract includes mechanisms for storing and retrieving metadata associated with each NFT.

b) Music Transaction Contract Implementation

The main transactional features of the platform are governed by this contract. Before transactions are enabled, functions are put in place to verify NFT ownership. This guarantees that only the legitimate owner can sell or transfer ownership of music, for example. Transactions involving the buying and selling of music are made simpler by smart contract features. Events brought about by transactions update ownership records and, in the case of sales, distribute profits to the rightful owners. Interaction with the NFT contract must be smooth. In order to verify ownership and guarantee consistency in ownership data, the music transaction contract collaborates with the NFT contract.

c) Royalty Distribution Contract Implementation

The royalty distribution contract automates the process of compensating artists using preset rules. The royalty distribution contract automates artist compensation based on predefined rules. Functions within the contract calculate the royalties owed to artists for each transaction, factoring in transaction fees and revenue from NFT sales. The smart contract's logic automatically transfers the estimated royalties directly to artists' wallets, eliminating the need for intermediaries and providing a more transparent and efficient payment system. Events are logged in the contract to create an auditable record of royalty payments, ensuring transparency for all parties involved. Testing is a crucial step to ensure the reliability and security of the smart contracts. Each function undergoes unit testing to verify its accuracy, with individual components tested in isolation to ensure they work as intended. Extensive testing is also done to ensure interoperability between different smart contracts, confirming that they work together seamlessly. Simulations are conducted for various scenarios, such as ownership transfers, royalty distributions, and unique cases, to evaluate the contracts' robustness and performance in dynamic situations. The iterative testing process allows for continuous improvements and the resolution of any issues or vulnerabilities that arise during testing.

B. IPFS Integration

The integration of the Interplanetary File System (IPFS) into our decentralized music player platform is crucial for decentralized storage and access to music files. IPFS provides a distributed, resilient file storage and retrieval system, ensuring that music files remain accessible and immutable. The integration process involves setting up IPFS nodes, handling file uploads and retrievals, ensuring data integrity, and implementing redundancy measures to safeguard against data loss. This approach enhances the platform's decentralized nature, providing reliable and secure access to music files without relying on centralized servers.

a) *IPFS Node Setup*

The initial step in integrating IPFS is setting up the IPFS nodes. This involves configuring the nodes to ensurethey meet the platform's requirements, which includes establishing peer-to-peer communication and enabling network discovery. Seamless connectivity between the IPFS nodes and the Ethereum blockchain is crucial for enabling smooth data exchange, as this connection forms the foundation of the decentralized storage system. IPFS nodes are deployed in a distributed manner to provide redundancy and fault tolerance, ensuring that music files remain accessible even if certain nodes go offline. This distributed architecture enhances the reliability and resilience of the platform.

b) File Upload and Retrieval

IPFS integration allows users to upload and retrieve audio files safely. A method was created to create a content identifier (CID) for every file that was submitted in order to facilitate user interaction. This CID serves as a special identification code for the file. By doing this, users were also able to use the CID associated with each file to download music files from IPFS. This process enables users to access their music files in a secure and efficient manner.

Ensuring the availability and integrity of music files stored on IPFS is essential. Checksum verifications were utilised to ensure data integrity when downloading music files via IPFS. It involves creating a checksum—a distinct

number obtained from the data—and comparing it to a checksum that was previously generated in order to check for any changes or corruption in the data. This process verifies that the recovered file and the one the user first uploaded are identical. To lessen the chance of data loss, IPFS redundancy measures were examined. This involves copying data across multiple IPFS nodes to guarantee that it remains available even in the case a failure.

c) Integration with Smart Contracts

IPFS integration is necessary for our smart contracts to associate music files with ownership-reflective NFTs. Because each music file's CID is recorded on IPFS within the NFT information, the ownership of an NFT is instantly linked to the music file it relates to. Secure access controls were implemented to ensure that the associated music file on IPFS is only accessible by the rightful owner of an NFT. IPFS integration is necessary for our smart contracts.

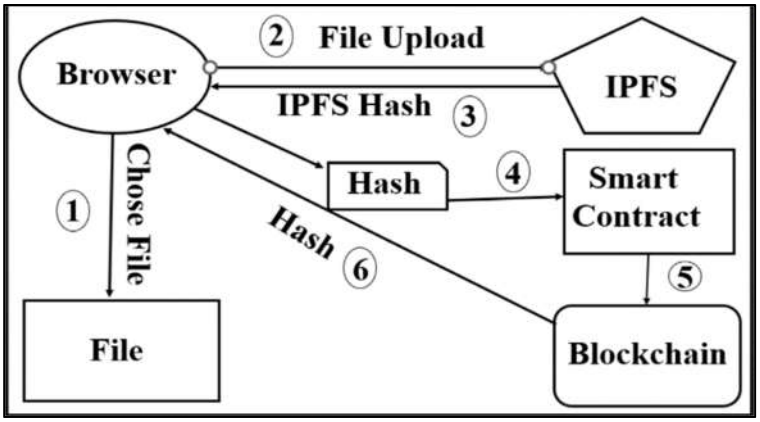

Fig. 4. Interaction of music platform with IPFS

C. NFT Implementation

The deployment of Non-Fungible Tokens (NFTs) is a crucial aspect of the decentralized music player platform, enabling the representation of individual ownership rights for music files. Smart contracts are employed to create, manage, and transfer these NFTs, providing artists and users with a transparent and secure method to interact with digital assets. This system ensures that ownership and rights over music files are clearly defined and protected, fostering trust and reducing the risk of unauthorized usage or copyright infringement.

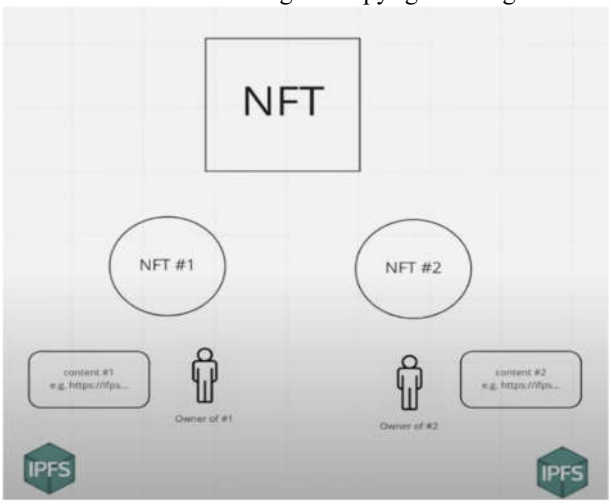

Fig. 5. Flow of nft token upto ipfs storing.

a) NFT Creation and Minting

NFTs The ERC-721 token standard is used to mint NFTs on the platform, guaranteeing that each token is distinct and non-fungible and signifying ownership of a certain music file. The ERC-721 standard offers versatility by supporting the development of both enumerable and non-enumerable tokens and enabling a transparent approval process. The artist's name, track title, album, genre, publishing year, IPFS-Hash, and other pertinent information are all included in each NFT. To guarantee that the NFT is associated with the music file, this metadata is linked to the token ID and saved on IPFS. Any updates or changes made to the music file are reflected in the metadata, guaranteeing accuracy and openness. When a new music file is uploaded to the platform, a corresponding new NFT is minted to signify its ownership. To maintain the integrity of the token creation process, only authorized users, such as administrators or artists, are permitted to mint new NFTs. This controlled access helps ensure the authenticity of the NFTs and the digital assets they represent.

4o.

a) NFT Creation and Minting

A transfer function built within the smart contract enables the existing NFT owner to move ownership to a different address. The ownership records are updated in accordance with the ownership verification function. A portion of the transaction value may be designated as a royalty fee to be given to the original artist during the transfer of an NFT. The smart contract ensures that artists get paid for the usage of their work by enforcing this royalty rate.

c) Royalty Distribution

The smart contract includes the justification for determining and distributing royalties to artists. This calculation is based on pre-established rules, such as a set fee per transaction or a portion of the sale price. After an NFT is transferred and the royalty fee is triggered, the smart contract immediately deducts and pays the royalty fee to the artist's wallet. This process is transparent and unalterable to ensure that artists receive just compensation for their work.

D. Encryption of Audio Files

Audio files uploaded to the decentralised music platform need to be encrypted in order to safeguard the content's security and privacy. Users upload audio files to the platform's backend. The platform generates a unique encryption key for the submitted audio file using a secure random key generator. This key will be used for both the file's encryption and decryption. The audio file is encrypted using the Advanced Encryption Standard (AES) symmetric encryption technique. During the encryption process, the audio file is transformed from its original, unencrypted state to a ciphertext. The encrypted audio file and the encryption key are stored in a safe place. The encrypted file is stored on IPFS for decentralised storage, and the encryption key is securely stored in a key management system. The file name, uploader information, and encryption key identification are among the metadata about the encrypted file that are stored on the blockchain. This metadata allows the platform to link the encrypted file to the corresponding encryption key. The platform employs access control methods to ensure that only authorised users can access the encryption keys and decrypt the audio files. When a user requests to play an encrypted audio file, the platform receives the encrypted file along with the corresponding encryption key. structure. The platform retrieves the encryption key associated with the requested audio file by logging into the key management system. The platform decrypts the encrypted audio file using the same symmetric encryption technique that was used for encryption and the recovered encryption key. Through streaming, the decrypted audio file is transferred to the user's device. The user's device can now play the audio file after it been decrypted. The decryption process protects user privacy by preventing unauthorised access and ensures the audio file is secure throughout transmission.

E. Integration of Hardhat console

We are integrating smart contracts to manage the storage and retrieval of music metadata on the Ethereum blockchain as part of our Web 3.0 music player application, using a Hardhat-based blockchain. Hardhat serves as the development framework for compiling, testing, and deploying these smart contracts. Specifically, we are building a contract (MusicPlayer.sol) that allows users to add songs and stores details such as the song title, artist name, URL, and owner address. These smart contracts are deployed to a local or testnet Ethereum network via Hardhat’s

deployment scripts, ensuring secure and transparent interactions. On the frontend, a React.js application connects to the deployed smart contract using frameworks like Web3.js and Ethers.js. Users can add new music to the blockchain, with the music data stored in a decentralized manner, ensuring integrity and verifying ownership. The React app delivers a decentralized music player experience by retrieving and displaying tracks from the blockchain. MetaMask is used for secure transactions and account management, allowing users to interact directly with their music data without relying on centralized servers. This integration highlights the power of Web 3.0 technology, enabling decentralized, trustless processes and giving users full control over their digital assets.

F. Transactions over blockchain

The MetaMask browser extension allows users to interact with Ethereum-based decentralized applications (dApps) and the Ethereum blockchain directly from their web browsers. Integrating MetaMask into the decentralized music platform enhances the user experience and provides several benefits. When users install MetaMask, they create a new Ethereum wallet, which is utilized for managing Ethereum-based tokens, such as the ERC-721 tokens representing music files on the platform, as well as for holding Ether (ETH). This integration facilitates seamless transactions, allowing users to easily buy, sell, and trade music files while maintaining control over their digital assets. MetaMask prompts users to review and sign transactions before they can be completed on the decentralized music platform. For instance, when purchasing an NFT that represents a music file, the user confirms the transaction within MetaMask, using their private key to sign it. Smart contracts on the platform can interact with MetaMask to facilitate transaction processing and verify user signatures. For example, a smart contract can validate the transaction signature from MetaMask before transferring ownership of the NFT to the user. MetaMask enables secure communication between the Ethereum blockchain and the user's browser, reducing the risk of unauthorized access to user data and transactions. Additionally, MetaMask allows users to choose between the Ethereum main net and various testnets. This flexibility is beneficial for developers, enabling them to test their smart contracts on testnets before deploying them to the mainnet. Overall, MetaMask enhances the user experience on the decentralized music player platform by providing a secure and convenient way to interact with Ethereum and manage digital assets like NFTs that represent music files.

G. Transactions over blockchain

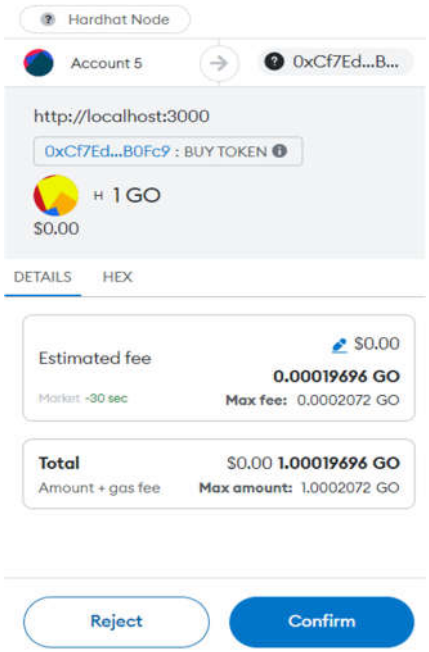

Fig 6. Permission asking for ether transfer in Metamax extention

IV. RESULTS

The decentralized music platform's smart contracts have been successfully deployed on the Ethereum blockchain. Events related to NFT creation, ownership transfers, and royalty distributions are logged within these contracts, providing transparency and auditability for all platform transactions. To minimize transaction costs and enhance contract efficiency, gas optimization techniques have been implemented, including the use of efficient data structures and a reduction in storage operations. As a result, the smart contracts demonstrate impressive processing efficiency, with transaction confirmation times averaging between 15 to 20 seconds. This efficiency ensures prompt transaction processing, contributing to a responsive user experience. Scalability was a key focus during development, and there are plans to integrate layer 2 scaling solutions into the smart contracts in the future. Technologies such as zk-SNARKs and optimistic rollups will further enhance the platform's scalability and transaction throughput. The platform's royalty distribution system has proven effective in ensuring that creators receive fair compensation. Compared to traditional music industry licensing models, the decentralized music platform offers a more transparent and equitable distribution of royalties. By eliminating intermediaries, artists and creators retain a larger share of the revenue generated by their music. Royalties are distributed to stakeholders and artists on a monthly basis, ensuring timely payments for their contributions to the platform.

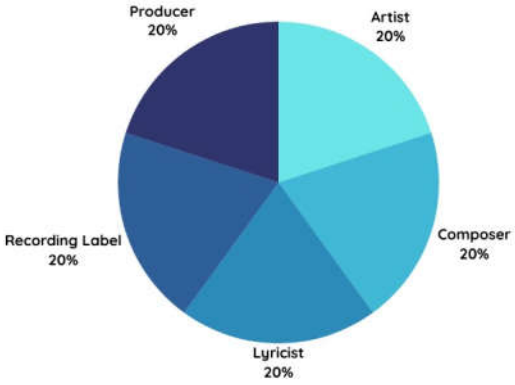

Fig 7. Distribution of a fair compensation scale

CONCLUSION

The creation of a decentralised music platform that provides an open, equitable, and effective environment for both listeners and musicians represents a major breakthrough in the music industry. This platform addresses important issues confronting the music industry, including copyright protection, royalty distribution, and user engagement, by integrating blockchain technology, smart contracts, NFTs, encryption, and MetaMask. To automate crucial procedures and offer equitable and transparent pay for artists and stakeholders, smart contracts for NFT generation, royalty distribution, and access control have been developed. The platform's capacity to generate, trade, and administer NFTs—a stand-in for music files—has radically changed the way that music is bought and sold and provided musicians with new revenue streams.

The platform's decentralised structure has given users more control over their music and royalties, and the incorporation of MetaMask has enhanced the user experience by offering a reliable and secure method of carrying out network transactions. Scalability will be a major challenge as the platform develops, especially with the addition of layer 2 scaling solutions and community governance structures to improve user adoption and interoperability. All things considered, the decentralised music platform has shown that it has the ability to fundamentally change the music industry by providing listeners and artists with a vibrant, dynamic, and inclusive community.

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